WHAT IS CLAIMED IS:

1.   A hydrogen gas sensor comprising:

a proton-conductive layer formed of a polymer electrolyte;

first and second electrodes provided in contact with the proton-conductive layer;

a diffusion-rate limiting portion disposed between the first electrode and an atmosphere of a gas under measurement containing hydrogen;

a circuit for applying a voltage between the first and second electrodes such that hydrogen introduced from the atmosphere via the diffusion-rate limiting portion undergoes dissociation, decomposition, or reaction to produce protons on the first electrode, and for determining the hydrogen concentration of the gas under measurement based on a saturation current which flows as a result of conduction of protons from the first electrode to the second electrode via the proton-conductive layer; and

means for conducting protons from the first electrode to the second electrode at a rate that is greater than a rate at which protons are produced from hydrogen introduced onto the first electrode via the diffusion-rate limiting portion.

2.   A hydrogen gas sensor comprising:

a proton-conductive layer formed of a polymer electrolyte;

first and second electrodes and a reference electrode provided in contact with the proton-conductive layer;

a diffusion-rate limiting portion disposed between the first electrode and an atmosphere of a gas under measurement containing hydrogen;

a circuit for applying a voltage between the first and second electrodes such that a constant voltage develops between the first electrode and the reference electrode, and such that hydrogen gas introduced from the atmosphere via the diffusion-rate limiting portion undergoes dissociation, decomposition, or reaction to produce portions on the first or second electrode, and for detecting the hydrogen concentration of the gas under measurement based on a saturation current which flows as a result of conduction of protons via the proton-conductive layer; and

means for conducting protons from the first electrode to the second electrode at a rate that is greater than a rate at which protons are produced from hydrogen introduced onto the first electrode via the diffusion-rate limiting portion.

3.   The hydrogen gas sensor as claimed in claim 1, wherein the proton conduction rate is not substantially affected by H_2O concentration or CO concentration in the gas under measurement.

4.   The hydrogen gas sensor as claimed in claim 2, wherein the proton conduction rate is not substantially affected by H_2O concentration or CO concentration in the gas under measurement.

5.   The hydrogen gas sensor as claimed in claim 1, further comprising a solution containing a polymer electrolyte arranged at an interface

between the proton-conductive layer and the first electrode and/or the second electrode.

6.   The hydrogen gas sensor as claimed in claim 2, further comprising a solution containing a polymer electrolyte arranged at an interface between the proton-conductive layer and the first electrode and/or the second electrode.

7.   The hydrogen gas sensor as claimed in claim 1, wherein the first and second electrodes are positioned in an opposed manner to sandwich the proton-conductive layer therebetween.

8.   The hydrogen gas sensor as claimed in claim 2, wherein the first and second electrodes are positioned in an opposed manner to sandwich the proton-conductive layer therebetween.

9.   The hydrogen gas sensor as claimed in claim 1, wherein

a current (a) flowing between the first and second electrodes is measured under severe conditions for proton conduction, upon application of a sufficiently high voltage between the first and second electrodes in a state in which the gas-diffusion resistance of the diffusion-rate limiting portion is rendered sufficiently small;

a saturation current (b) flowing between the first and second electrodes is measured under favorable conditions for proton conduction, upon application of a sufficiently high voltage between the first and second

electrodes in a state in which the gas-diffusion resistance of the diffusion-rate limiting portion is rendered larger; and

the gas-diffusion resistance of the diffusion-rate limiting portion is set such that the current (a) > the saturation current (b).

10. The hydrogen gas sensor as claimed in claim 2, wherein

a current (a) flowing between the first and second electrodes is measured under severe conditions for proton conduction, upon application of a sufficiently high voltage between the first and second electrodes in a state in which the gas-diffusion resistance of the diffusion-rate limiting portion is rendered sufficiently small;

a saturation current (b) flowing between the first and second electrodes is measured under favorable conditions for proton conduction, upon application of a sufficiently high voltage between the first and second electrodes in a state in which the gas-diffusion resistance of the diffusion-rate limiting portion is rendered larger; and

the gas-diffusion resistance of the diffusion-rate limiting portion is set such that the current (a) > the saturation current (b).

11. The hydrogen gas sensor as claimed in claim 9, wherein the gas-diffusion resistance of the diffusion-rate limiting portion is set such that the ratio of current (a) to the saturation current (b) is in the range of from 1 to 1.15.

12. The hydrogen gas sensor as claimed in claim 10, wherein the gas-diffusion resistance of the diffusion-rate limiting portion is set such that the ratio of current (a) to the saturation current (b) is in the range of from 1 to 1.15.

13. The hydrogen gas sensor as claimed in claim 1, for measurement of hydrogen concentration of a fuel gas for a polymer electrolyte fuel cell.

14. The hydrogen gas sensor as claimed in claim 2, for measurement of hydrogen concentration of a fuel gas for a polymer electrolyte fuel cell.

15. The hydrogen gas sensor as claimed in claim 1, wherein the gas diffusion resistance of the diffusion-rate limiting portion is set such that the saturation current which flows between the first and second electrodes, upon application of a sufficiently high voltage between the first and second electrodes, in the presence of said diffusion-rate limiting portion, under favorable conditions for proton conduction, is lower than a current which can flow between the first and second electrodes, in the absence of a diffusion-rate limiting portion, or with a diffusion-rate limiting portion of low gas-diffusion resistance, but under severe conditions for proton conduction.

16. The hydrogen gas sensor as claimed in claim 2, wherein the gas diffusion resistance of the diffusion-rate limiting portion is set such that the saturation current which flows between the first and second electrodes, upon

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application of a sufficiently high voltage between the first and second electrodes, in the presence of said diffusion-rate limiting portion, under favorable conditions for proton conduction, is lower than a current which can flow between the first and second electrodes, in the absence of a diffusion-rate limiting portion, or with a diffusion-rate limiting portion of low gas-diffusion resistance, but under severe conditions for proton conduction.

17.   A method of selecting the gas-diffusion resistance of the diffusion-rate limiting portion of the hydrogen gas sensor as claimed in claim 1, comprising the steps of:

measuring a current (a) flowing between the first and second electrodes under severe conditions for proton conduction, upon application of a sufficiently high voltage between the first and second electrodes in a state in which the gas-diffusion resistance of the diffusion-rate limiting portion is rendered small;

measuring a saturation current (b) flowing between the first and second electrodes under favorable conditions for proton conduction, upon application of a sufficiently high voltage between the first and second electrodes, in a state in which the gas-diffusion resistance of the diffusion-rate limiting portion is rendered larger; and

selecting the gas-diffusion resistance of the diffusion-rate limiting portion such that, when the saturation current (b) is measured with the selected gas-diffusion resistance, the current (a) > the saturation current (b).

18.   A method of selecting the gas-diffusion resistance of the diffusion-rate limiting portion of the hydrogen gas sensor as claimed in claim 2, comprising the steps of:

measuring a current (a) flowing between the first and second electrodes under severe conditions for proton conduction, upon application of a sufficiently high voltage between the first and second electrodes in a state in which the gas-diffusion resistance of the diffusion-rate limiting portion is rendered small;

measuring a saturation current (b) flowing between the first and second electrodes under favorable conditions for proton conduction, upon application of a sufficiently high voltage between the first and second electrodes, in a state in which the gas-diffusion resistance of the diffusion-rate limiting portion is rendered larger; and

selecting the gas-diffusion resistance of the diffusion-rate limiting portion such that, when the saturation current (b) is measured with the selected gas-diffusion resistance, the current (a) > the saturation current (b).

19.   The hydrogen gas sensor is claimed in claim 1, wherein a ratio (saturation current flowing between the first and second electrodes at H_2O = 30%)/(saturation current flowing between the first and second electrodes at H_2O = 10%) falls within a range of 1 to 1.5, wherein the H_2O content is the H_2O content of the atmosphere of a gas under measurement.

20.   The hydrogen gas sensor is claimed in claim 2, wherein a ratio (saturation current flowing between the first and second electrodes at H_2O = 30%)/(saturation current flowing between the first and second electrodes at H_2O = 10%) falls within a range of 1 to 1.5, wherein the H_2O content is the H_2O content of the atmosphere of a gas under measurement.

21.   The hydrogen gas sensor as claimed in claim 1, wherein a ratio (saturation current flowing between the first and second electrodes at CO = 1000 ppm)/(saturation current flowing between the first and second electrodes at CO = 0 ppm) falls within a range of 0.9 to 1, wherein the CO content is the CO content of the atmosphere of a gas under measurement.

22.   The hydrogen gas sensor as claimed in claim 2, wherein a ratio (saturation current flowing between the first and second electrodes at CO = 1000 ppm)/(saturation current flowing between the first and second electrodes at CO = 0 ppm) falls within a range of 0.9 to 1, wherein the CO content is the CO content of the atmosphere of a gas under measurement

23.   The hydrogen gas sensor as claimed in claim 1, wherein the proton-conductive layer has a proton conductivity relative to a diffusion resistance of said diffusion-rate limiting portion such that the saturation current varies less than 5% when the H_2O concentration of the gas under measurement is changed from 10% to 30%.

24.   The hydrogen gas sensor as claimed in claim 1, wherein the proton-conductive layer has a proton conductivity relative to a diffusion

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resistance to said diffusion-rate limiting portion such that the ratio of

saturation current at an H_2O concentration of 30% of the gas under

measurement to an H_2O concentration of 10% of the gas under measurement is

about 1.041 or less.

25.   A hydrogen gas sensor comprising:

a proton-conductive layer formed of a polymer electrolyte;

first and second electrodes disposed on opposite surfaces, respectively,

of the proton-conductive layer so that the first electrode and the second

electrode sandwich the proton-conductive layer;

a diffusion-rate limiting portion disposed between the first electrode

and an atmosphere of a gas under measurement containing hydrogen, the

diffusion-rate limiting portion comprises a dense body having a through-hole

having an opening diameter of 1 μm or higher; and

a circuit for applying a voltage between the first and second electrodes

such that hydrogen introduced from the atmosphere via the diffusion-rate

limiting portion undergoes dissociation, decomposition, or reaction to produce

protons on the first electrode, and for determining the hydrogen concentration

of the gas under measurement based on a saturation current which flows as a

result of conduction of protons from the first electrode to the second electrode

via the proton-conductive layer, and

said sensor having a proton-conducting rate from the first electrode to

the second electrode that is greater than a rate at which protons derived from

hydrogen are introduced onto the first electrode via the diffusion-rate limiting portion.

26. The hydrogen gas sensor as claimed in claim 25, wherein the opening diameter of the through-hole is 30 µm or higher.

27. A hydrogen gas sensor comprising:

a proton-conductive layer formed of a polymer electrolyte;

first and second electrodes disposed on opposite surfaces, respectively, of the proton-conductive layer so that the first electrode and the second electrode sandwich the proton-conductive layer;

a reference electrode formed on the surface of the proton-conductive layer on which the second electrode is formed;

a diffusion-rate limiting portion disposed between the first electrode and an atmosphere of a gas under measurement containing hydrogen, the diffusion-rate limiting portion comprises a dense body having a through-hole having an opening diameter of 1 µm or higher; and

a circuit for applying a voltage between the first and second electrodes such that a constant voltage develops between the first electrode and the reference electrode, and such that hydrogen gas introduced from the atmosphere via the diffusion-rate limiting portion undergoes dissociation, decomposition, or reaction to produce protons on the first or second electrode, and for detecting the hydrogen concentration of the gas under measurement

based on a saturation current which flows as a result of conduction of protons via the proton-conductive layer, and

said sensor having a proton-conducting rate from the first electrode to the second electrode that is greater than a rate at which protons derived from hydrogen are introduced onto the first electrode via the diffusion-rate limiting portion.

28.   The hydrogen gas sensor as claimed in claim 27, wherein the opening diameter of the through-hole is 30 μm or higher.